

Ocean models, but what if we made them $100\times$ faster?

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Abstract

GPU computing has recently transformed high-performance computing (HPC) by providing substantial computational power and energy efficiency. However, ocean modeling, vital for climate and environmental research, remains primarily CPU-based, especially within the realm of unstructured models. Our work introduces a 2D/3D GPU ocean model based on the Discontinuous Galerkin (DG) method, overcoming challenges in adapting unstructured models to GPU architectures, traditionally optimized for structured memory access.

Our contributions include memory efficiency optimizations and a novel “cell layout” memory structure. It strikes a balance between performance during the assembly, and speed of the resolution of the many banded linear systems that arise. Our GPU-accelerated model achieves an average $50\times$ to $100\times$ speedup over CPU counterparts, making a GPU equivalent to 1500–2500 CPU cores. These kind of speedups, while theoretically predicted, are rarely achieved in practice, especially for unstructured models and implicit processes.

This research offers unprecedented computational efficiency for complex oceanic simulations, with direct ecological applications. It is already transforming our research group, where fine simulations that would previously require a year of computation can now be completed in just under a week.